were taken in a motorized water phantom using small detectors (Razor stereotactic diode and PFD, IBA Dosimetry). In addition, MLC transmission was measured using a Farmer ion chamber. MLC model parameters (transmission, offset, leaf tip width, tongue-and-groove) were optimized to maximize the agreement between measurements and calculations. Model assessment was performed using a set of highly intensity-modulated MLC geometrical patterns, designed to enhance tongue-and-groove, transmission and offset/leaf-tip effects. For those fields, planar dosimetry was carried out with GafChromic EBT3 films. Clinical validation was performed evaluating TG-119 cases along with 25 DMLC and 10 VMAT clinical plans. Plan-specific quality assurance was performed with a 2D-array (MatriXX, IBA Dosimetry) and gamma-index metric was used to assess the agreement between planned and measured dose distributions. A 2%/2mm criterion was used with both local (LN) and global (GN) normalization.

Results: Optimized MLC parameters were: transmission 0.018, position-offset 0.04cm, tongue-and-groove 0.05cm, leaf tip width 0.3cm. Average and standard deviation (SD) values of gamma index pass-rates were: for geometrical patterns: 92.8%, SD=5.1%(LN); 95.5%, SD=2.5%(GN). For TG-119 plans: 97.1%, SD=4.4%(LN); 99.7%, SD=0.7%(GN). For DMLC clinical plans: 97.0%, SD=3.7% (LN); 98.8%, SD=2.6%(GN). For VMAT plans 90.1%, SD=4.0% (LN); 96.5%, SD=2.1% (GN). Critical regions dominated by tongue-and-groove and rounded-leaf-tip effect showed a very good agreement between measurements and calculations (see Fig.1).

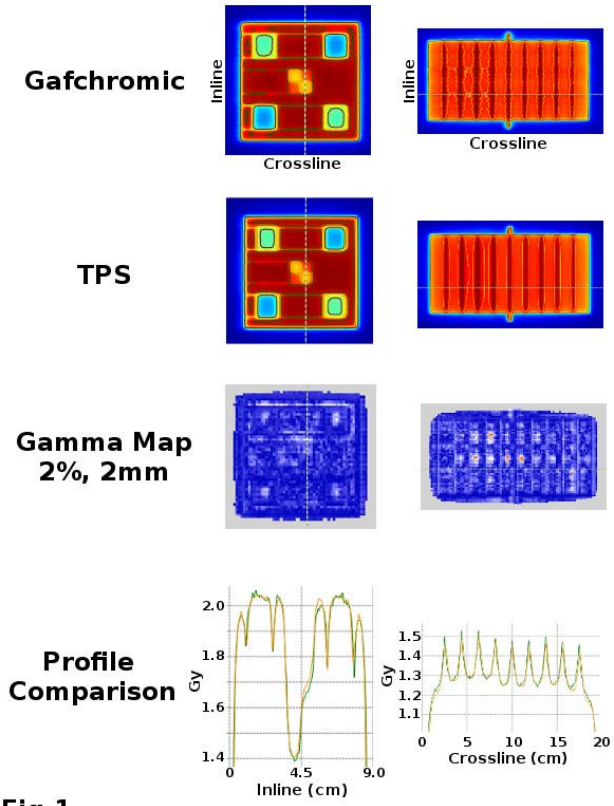


Fig.1

Conclusion: Results demonstrate the followed procedure leads to a proper optimization of the MLC model in RayStation, leading to clinically acceptable gamma index pass-rates. The needed additional measurements can be easily integrated as a subset of the standard measurements required for the commissioning of the RayStation TPS.

PO-0807

3D and 4D dose calculations for tumour-tracking irradiation of lung/liver tumours using gimbaled linac

Y. Iizuka[1], N. Ueki[2], Y. Matsuo[1], Y. Ishihara[1], K. Takayama[3], M. Nakamura[1], T. Mizowaki[1], M. Kokubo[3], M. Hiraoka[1]
[1]Kyoto University, Department of Radiation Oncology and Image-Applied therapy, Kyoto, Japan
[2]Hyogo Prefectural Amagasaki General Medical Center, Department of Radiation Oncology, Amagasaki, Japan
[3]Institute of Biomedical Research and Innovation, Division of Radiation Oncology- Department of Image-based Medicine, Kobe, Japan

Purpose or Objective: To compare dose-volume metrics calculated with the four-dimensional (4D) Monte Carlo (MC) and three-dimensional (3D) dose evaluation systems in dynamic tumor tracking (DTT) irradiation for lung or liver tumors.

Material and Methods: Twenty patients with lung tumors and 15 patients with liver tumors who underwent DTT irradiation using a gimbal-mounted linac were enrolled in this study. During computed tomography (CT) simulation, 4DCT under free breathing and exhale breath-hold CT were performed. Planning target volume (PTV) for DTT was calculated using the gross tumor volume (GTV) delineated on a reference CT scan (exhale phase in the 4DCT or exhale breath-hold CT) by adding asymmetric margins to compensate for possible errors due to the DTT. The 6 to 9 non-coplanar ports of the 6-MV X-ray were set to each PTV. Doses were calculated for the reference CT using a commercially available treatment planning system (TPS). At the same time, 4DMC dose evaluation was performed for 10 respiratory phases of 4DCT using an in-house dose calculation system based on the MC algorithm, considering the gimbal rotation. The doses calculated for 10 phases were accumulated using deformable image registration software for the lung tumor patients, whereas mean values of the dose-volume metrics were evaluated for the liver tumor patients. The difference between the doses calculated with 4DMC (4D doses) and those calculated for the reference CT scan with TPS (3D doses) were investigated for the following dose-volume metrics: the percentage of dose that covers 95% of the GTV (GTV D95), the max dose received by the spinal cord (Cord max), the percentage of lung volume that received more than 20 Gy and 5 Gy irradiation (Lung V20 and Lung V5, respectively) in patients with lung tumors, and the mean dose and percentage of liver volume that received more than 20 Gy irradiation (Liver mean and Liver V20, respectively) in patients with liver tumors.

Results: The mean values of the dose-volume metrics for the 4D doses were as follows: 94.1% (range, 83.8–99.7%) GTV D95, 9.7 Gy (range, 1.8–22.0 Gy) Cord max, 4.9% (range, 1.9–13.7%) Lung V20, 19.2% (range, 7.2–30.7%) Lung V5, 10.0 Gy (range, 5.2–15.2) Liver mean,15.5% (range, 8.2–27.7%) Liver V20 The mean differences in the dose-volume metrics for the 3D and the 4D doses were as follows: 0.5% (range, -7.4–4.8%) GTV D95, 0.1 Gy (range, -2.5–1.8 Gy) Cord max, 0.1% (range, -0.8–1.4%) Lung V20, 0.3% (range, -1.6–2.1%) Lung V5, 0.1 Gy (range, -1.6–1.1 Gy) Liver mean, and -1.0% (range, -1.7–3.1%) Liver V20. There were no statistical significant differences in these dose-volume metrics evaluated by paired t-test.

Conclusion: The 3D doses calculated with TPS for the target tumor and organs at risk were almost equal to those calculated with 4DMC. 3D dose could be used as a substitution for 4DMC calculation. However, the dose to the spinal cord was underestimated by a maximum of 2.5 Gy.

PO-0808

Validation of a clinical peripheral photon dose model: prostate IMRT irradiation of Alderson phantom

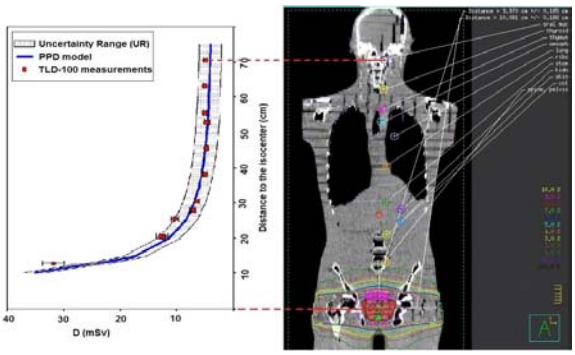
B. Sanchez-Nieto[1], L. Irazola[2], M. Romero-Expósito[3], J. Terrón[4], F. Sánchez-Doblado[5]
[1]Pontificia U-dad Catolica de Chile, Insitute of Physics, Santiago, Chile

[2]*Universidad de Sevilla, Departamento de Fisiología Médica y Biofísica- Universidad de Sevilla- Spain, Sevilla, Spain*
[3]*Universitat Autònoma de Barcelona, Departamento de Física, Barcelona, Spain*
[4]*Hospital Universitario Virgen Macarena, Servicio de Radiofísica, Sevilla, Spain*
[5]*Universidad de Sevilla, Departamento de Fisiología Médica y Biofísica, Sevilla, Spain*

Purpose or Objective : Unwanted peripheral doses (PD) from external beam radiotherapy (RT) are associated with increased incidence of second cancers. PD estimations after RT are becoming highly relevant due to the larger cancer incidence as well as survival rates. Additionally, an accurate knowledge of out-of-field doses is of importance when treating children, pregnant patients and those with implantable electronic devices [1]. Our group has developed a novel peripheral photon dose (PPD) model [2] which includes intensity modulated treatments. This model estimates out-of-field doses (i.e., beyond the commercial TPS limits -around 10 cm from the field edge) received by individual patients undergoing any RT isocentric technique.
The aim of this work was the experimental validation of the model in a number of points inside the Alderson Radiation Therapy phantom (ART) irradiated with an IMRT prostate plan. This exercise is part of the process toward the implementation of the model onto a commercial TPS.

Material and Methods: A Siemens Primus linac was used to deliver a 6 MV prostate IMRT treatment (896 MU and 7 incidences, equivalent to 2 fractions of the treatment). TLD-100 pairs of dosimeters were inserted at phantom holders, placed outside the 1% isodose as shown in the coronal plane of the figure. Positions were selected as being representative of cancer-at-risk organs. TLD-100 readings were converted into doses, through a calibration factor which considers the spectral condition outside the field, and then compared to PPD model estimates [2]. Measured leakage outside the field resulted 4 μGy/MU. Peripheral photon equivalent dose (PPED) to organs was also computed using PERIPHOCAL [2] (a MATLAB® GUI piece of software which considers a basic patient model with scaled dimensions from Cristy phantom [3]).

Results: Plot at the figure depicts the estimated and measured photon equivalent doses (mSv) at 11 points for studied case (identified on the coronal plane of the phantom). Uncertainty Range (UR) corresponds to ±2 mSv and the error bars represent the ±6 % global uncertainty estimated for the TLDs in the out-of-field area2.
Figure.



Conclusion: Validation of a PPD calculation model [2] has been carried out in an Alderson phantom for an IMRT prostate treatment using TLD-100 detectors. Very good agreement has been found between the model and the experimental measurements. However, bigger differences have been found between dose to points and PPED to organs, which might suggests that the mathematical phantom and/or the escalation model used for estimating organ location/dimensions are not properly mimicking the anatomy of the Alderson phantom. This issue deserves further investigation before implementing the dose-to-organ model onto a commercial TPS.

Ref.
[1] http://dx.doi.org/10.1118/1.4925789
[2] Analytical model for photon peripheral dose estimation in radiotherapy treatments. Sánchez-Nieto B. et al. Biomed Phys Eng Express 2015: In press
[3] http://crpk.ornl.gov/resources/phantom.html

PO-0809

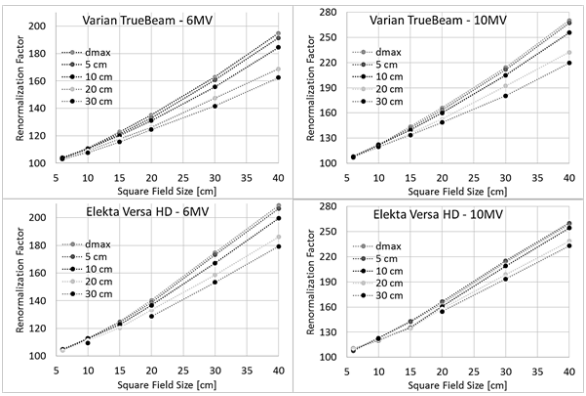
FFF beams from TrueBeam and Versa HD units: evaluation of the parameters for quality assurance

A. Fogliata[1], J. Fleckenstein[2], F. Schneider[2], M. Pachoud[3], S. Ghandour[3], H. Krauss[4], G. Reggiori[1], A. Stravato[1], F. Lohr[2], M. Scorsetti[1], L. Cozzi[1]
[1]*Humanitas Research Hospital, Radiation Oncology Dept, Rozzano-Milan, Italy*
[2]*University Medical Center Mannheim- University of Heidelberg, Dept. of Radiation Oncology, Mannheim, Germany*
[3]*Hôpital Riviera Chablais, Radiation Oncology Dept, Vevey, Switzerland*
[4]*Kaiser Franz Josef Spital, Radio-Oncology Dept., Vienna, Austria*

Purpose or Objective: Flattening filter free (FFF) beams generated by medical linacs are today clinically used for stereotactical treatments, thanks to their very high dose rate (up to four times the dose rate of the common flattened beams). Such beams differ from the standard flattened beams (FF) in the profile shape, that is strongly peaked on the beam central axis. However, FFF beams are not standard in terms of the parameters describing the field characteristics. Definitions of new parameters as *unflatness* and *slope* for FFF beams have been proposed, based on a renormalization factor for FFF profiles. With those factors the FFF dose fall-off at the field edge is superimposed with the corresponding (in nominal energy) flattened profile commonly normalized to 100% at the beam central axis. The present study aims to provide the renormalization factors for FFF beams of 6 and 10 MV generated by Varian TrueBeam and by Elekta Versa HD linacs. Estimation of the values of the new parameters (unflatness and slope) for the two units are also given.

Material and Methods: Dosimetric data from two Varian TrueBeam and two Elekta Versa HD linacs, all with 6 and 10 MV nominal accelerating potentials, FF and FFF modes have been collected. Renormalization factors were estimated according to Fogliata et al. procedure (Med.Phys. 2012,39) with the third derivative method, and parameters of *RenormFactor=(a+b*FS+c*depth)/(1+d*FS+e*depth)* have been fitted for FFF beams of both units and energies. Unflatness and slope parameters were computed. Dosimetric differences as beam penetration and surface dose were also assessed.

Results: Renormalization factors are summarized in the graphs here presented.



Once the FFF profiles have been renormalized, the unflatness and slope were computed. As an example of unflatness parameter, for a 20x20 cm2 field, it was estimated in the range (from dmax to 30 cm depth) of 1.248-1.317, and 1.304-